PCT
WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : H04B 7/26, H04M 11/00 H04Q 9/00 — A1

(11) International Publication Number: WO 94/00927

(43) International Publication Date: 6 January 1994 (06.01.94)

(21) International Application Number: PCT/US93/05078

(22) International Filing Date: 1 June 1993 (01.06.93)

(30) Priority data:
07/902,130 22 June 1992 (22.06.92) US

(71) Applicant: MOTOROLA INC. [US/US]; 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

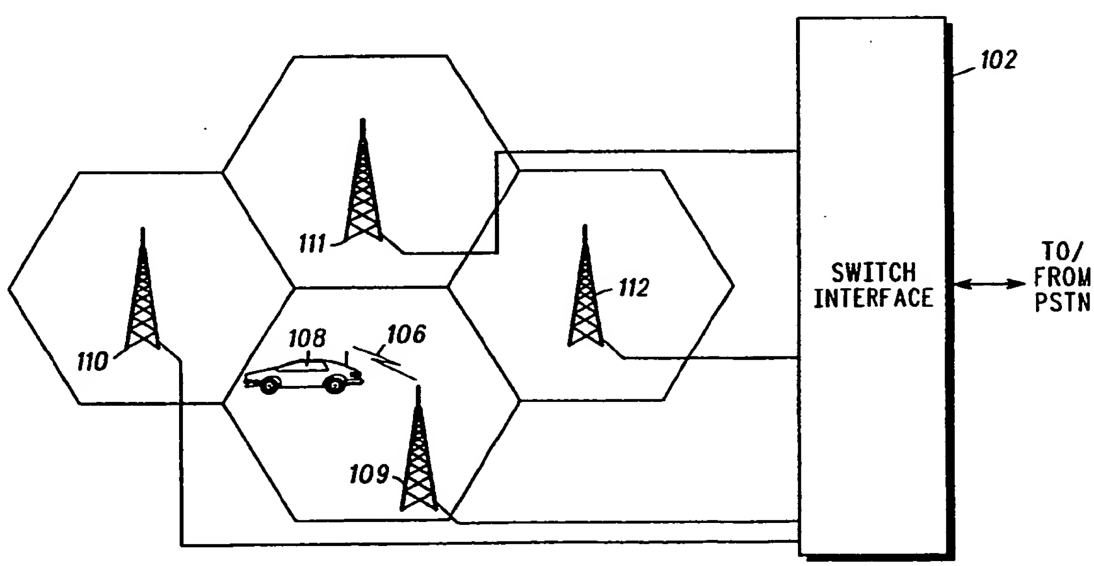
(72) Inventors: BONTA, Jeffrey, D. ; 1300 East Mayfair, Arlington Heights, IL 60004 (US). MENICH, Barry, J. ; 2680 College Hill, Schaumburg, IL 60173 (US).

(74) Agents: PARMELEE, Steven, G. et al.; Motorola Inc., Intellectual Property Dept./RAS, 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

(81) Designated States: BR, CA, FI, JP, SE.

Published
With international search report.

(54) Title: POWER LEVEL INCREASE DURING HANDOFF COMMAND TRANSMISSION



(57) Abstract

A base-site (109) communicating to a mobile (108) increases the power level of a transmission of a handoff command when required. The base-site (109) detects when handoff is required, and transmits the handoff command at a first power level (P1) which is essentially equal to the power level of the base-site (109) to mobile (108) voice communication power level. If the handoff command does not reach mobile (108), either after the elapse of a predetermined time period or some other predetermined triggering event, base-site (109) transmits the handoff command at a second, increased power level (P2).

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FR	France	MR	Mauritania
AU	Australia	GA	Gabon	MW	Malawi
BB	Barbados	GB	United Kingdom	NE	Niger
BE	Belgium	GN	Guinea	NL	Netherlands
BF	Burkina Faso	GR	Greece	NO	Norway
BG	Bulgaria	HU	Hungary	NZ	New Zealand
BJ	Benin	IE	Ireland	PL	Poland
BR	Brazil	IT	Italy	PT	Portugal
BY	Belarus	JP	Japan	RO	Romania
CA	Canada	KP	Democratic People's Republic of Korea	RU	Russian Federation
CF	Central African Republic			SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovak Republic
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	UA	Ukraine
DE	Germany	MG	Madagascar	US	United States of America
DK	Denmark	ML	Mali	UZ	Uzbekistan
ES	Spain	MN	Mongolia	VN	Viet Nam
FI	Finland				

POWER LEVEL INCREASE DURING HANDOFF COMMAND TRANSMISSION

Related Invention

Reference is made to U.S. Patent Application No. (Docket #CE02379R), "Alternate Base-Site Transmission of a Handoff Command in a Communication System" in behalf of Bonta et al., filed on the same date herewith, containing related subject matter and assigned to the assignee of the present invention.

Field of the Invention

The invention relates generally to cellular radiotelephone systems and more specifically to handoff of communication of a mobile in a cellular radiotelephone system.

Background of the Invention

Handing over from one radio-frequency (RF) channel to another in order to maintain a reasonable level of quality is a well known procedure in communications systems, specifically cellular radiotelephone systems. In todays cellular radiotelephone systems, the method of instructing a mobile to move from one RF channel to another is to transmit a digital message via a blank-and-burst (blank the voice transmission and burst the digital handoff message) technique in analog cellular radiotelephone systems and a frame stealing technique in digital cellular radiotelephone systems (such as time-division multiple access (TDMA) cellular radiotelephone systems). Given the cellular radiotelephone systems multi-path fading environment, the digital message, or handoff command, is encoded and repeated in such a way that the

receiving mobile has the best chance of decoding the message under adverse conditions. In addition, most cellular systems suffer from thermal noise or interference (or both) at various locations throughout the geographic area being served. At times, the noise can be quite substantial with respect to the desired signal. If the signal-to-noise (S/N) ratio is poor enough in the downlink direction (transmission from a base-site to a mobile), the probability of successfully sending a handoff command from a serving base-site to a given mobile is significantly impaired.

In an urban micro-cellular system environment where base-site antennas are typically the 5 to 10 meters above the street, the signal path from the serving base-site on a given street to a mobile on a perpendicular street can be obstructed by buildings. The pathloss from the serving base-site to the mobile can change for the worse 20-30 dB within 10-40 meters as the mobile turns a street corner (otherwise known as the "street corner effect"). Reaction time to this condition is essential since the S/N ratio degrades rapidly, and hence the quality of the call degrades rapidly. A handoff to an adjacent, alternate base-site (or cell) is required immediately in order to maintain the call. Since the mobile must receive a handoff command in order to perform handoff, a reasonable S/N ratio is essential for good probability of the mobile receiving and decoding the handoff command.

Unfortunately, the conditions described herein often result in a failed handoff attempt ultimately leading to a dropped call. To make matters worse, fast moving mobiles and intermittent blocking conditions (lack of available channels at alternate base-sites for handoff) add to the failed handoff problems as pathloss from the serving cell to the mobile increases. In this situation, the mobile has little chance of hearing a handoff command transmitted by the serving base-site.

Thus, a need exists for a communications system, and more specifically a cellular radiotelephone system, which provides an increased probability of a mobile receiving a handoff command, and

thus increasing the probability of handoff, in the adverse conditions experienced by cellular radiotelephone systems.

Summary of the Invention

A base-site communicates to a mobile via a signal transmitted at a first power level. The base-site, operating at the first power level, commences transmission of a handoff command to the mobile and increases the power level of the signal transmitted from the first power level to a second power level during transmission of the handoff command.

Brief Description of the Drawings

FIG. 1 generally depicts a cellular radiotelephone system which may beneficially employ the present invention.

FIG. 2 generally depicts a detailed block diagram of a base-site which may implement the present invention.

FIG. 3 generally depicts implementation of power level increase during handoff command transmission in a TDMA cellular radiotelephone system in accordance with the invention.

FIG. 4 generally depicts simulation results of power level increase during handoff command transmission in a TDMA cellular radiotelephone system in accordance with the invention.

Detailed Description of a Preferred Embodiment

FIG. 1 generally depicts a communication system, and more specifically a cellular radiotelephone system, which may beneficially employ the present invention. As depicted in FIG. 1, base-sites 109-112 are coupled to a switch interface 102, which

provides switching and interface functions between base-sites 109-112 and a public switched telephone network (PSTN). In the preferred embodiment, switch interface 102 may be either a Mobile services Switching Center (MSC) or a Base Station Controller (BSC). For purposes of example, base-site 109 communicates to a mobile 108 via a signal 106. In the preferred embodiment, signal 106 is a full duplex radio frequency (RF) signal having a downlink transmission (transmission from base-site 109 to mobile 108) frequency range between 935-960 MHz and an uplink transmission (transmission from mobile 108 to base-site 109) frequency range between 890-915 MHz. Also in the preferred embodiment, the cellular radiotelephone system depicted in FIG. 1 is a time-division multiple access (TDMA) cellular radiotelephone system, consequently, signal 106 has TDMA timeslots multiplexed thereon.

FIG. 2 generally depicts a detailed block diagram of base-sites 109-112 which may implement the present invention. As depicted in FIG. 2, base-sites 109-112 are generally comprised of an antenna 200 which receives and transmits signal 106 to mobile 108. Antenna 200 is coupled to a receiver 204 and a transmitter 210 via a duplexer 202. Duplexer 202 is essentially two bandpass filters, one having a frequency range between 935-960 MHz for downlink transmission via transmitter 210, and a second having a frequency range between 890-915 MHz for uplink reception by receiver 204. When signal 106 is transmitted by mobile 108, receiver 204 receives signal 106 and, using signal strength indication (SSI) block 214, monitors the signal level of signal 106. Output from SSI block 214 is input into control/equalizer board 206, which performs all necessary channel processing and provides coupling to channel equalizers 208. When SSI block 214 indicates that the level of signal 106 is below a predetermined threshold, control/equalizer board 206 commences transmission of a handoff command to mobile 108. At this point, control/equalizer board 206 will send the appropriate handoff command to transmitter 210 for transmission of the handoff command at a first power level P1 to mobile 108 via signal 106. If

base-site 109 does not receive an indication that handoff has properly occurred, control/equalizer board 206 will instruct PA control board 216 to increase the power level of signal 106 from the first power level P1 to a second power level P2 during transmission of the handoff command. This increase may either be a single-step increase or an incremental increase. If the increase is an incremental increase, the process of increasing the level of signal 106 during transmission of the handoff command is repeated until handoff of mobile 108 is complete, or the process eventually terminates itself.

For TDMA cellular radiotelephone systems, such as the group special mobile (GSM) Pan-European Digital Cellular System, the United States Digital Cellular (USDC) system described in EIA Standard IS-54, January 1991, printed in the USA, and the Japanese Digital Cellular (JDC) system described in Research and Development Center for Radio Systems (RCR) Standard 27A, January 1992, printed in Japan, a need for handoff can be detected by use of mobile 108. A need for handoff occurs when, for example, mobile 108, which is communicating to base-site 109 via signal 106, moves to a point where the quality of signal 106 (typically the power level of signal 106 as seen by mobile 108) degrades beyond a predetermined threshold. Since, when handoff is required, the quality of signal 106 has degraded beyond a predetermined threshold, transmission of a handoff command via signal 106 would likewise suffer from the same degradation. However, base-sites 109-112 incorporate variable power-level power amplifiers, thus if base-site 109 can be instructed to increase its output power by some level during the transmission of the handoff command to mobile 108, an increase of the probability that mobile 108 receives the handoff command, and a corresponding reduction of the rate of dropped calls, will occur.

FIG. 3 generally depicts power level increase during handoff command transmission in a TDMA cellular radiotelephone system in accordance with the invention. As depicted in FIG. 3, eight (8)

timeslots t0-t7 comprise frames F1-F68. Of course, other frames occur before and after frames F1-F68, but these frames are not depicted for clarity. Continuing, timeslots t0-t7 of frames F1-F68 are continuous in time, and are defined in GSM Recommendation 5.02, version 3.4.1, January, 1990. In the GSM configuration, timeslot t0 is dedicated to, inter alia, control channel (CCH) and broadcast channel (BCCH) information. The remaining timeslots t1-t7 of each frame F1-F68 are generally dedicated to voice transmission. When base-site 109 communicates to mobile 108 via signal 106, the voice communication occurs during a dedicated one timeslot (indicated by "V" shown in timeslot t3, FIG. 3) of each frame F1-F36.

Transmission of the handoff command (indicated by "HC" shown in timeslot t3, FIG. 3) to mobile 108 at an increased power level may occur after the detection of a predetermined triggering event. For example, in the embodiment depicted in FIG. 3, the predetermined triggering event is the elapse of a predetermined number of transmissions at a first power level. As depicted in FIG. 3, timeslot t3 of frame F1 depicts transmission of a handoff command HC at a power level P1. Transmission of the handoff command HC occurs during timeslot t3 for eight consecutive frames F1-F8. In this scenario, handoff command HC steals timeslot t3 from voice communication V. When transmission of the handoff command HC at the first power level P1 is completed, voice communication V continues for the next 26 frames F9-F34 at power level P1. If base-site 109, which is transmitting the timeslots depicted in FIG. 3, does not receive an indication that handoff has been completed (for example, a "CLEAR SOURCE" command from switch interface 102), base-site 109 will automatically increase the power level of the transmission of the handoff command HC during timeslot t3 of frames F35-F42 to a second power level P2. In this scenario, the handoff command is repeated every 34 frames, thus the triggering event would be the elapse of 34 frames, where eight frames have the handoff command transmitted during timeslot t3

at a first power level P1. At the end of transmission of handoff command HC at the second power level P2, base-site 109 continues voice communication V during frames F43-F68 at the first power level P1. At this point, base-site 109 may either continue increasing the level of transmission of the handoff command HC during subsequent frames, or may terminate the entire handoff procedure.

Other predetermined triggering events may also signal base-site 109 to increase power level during transmission of the handoff command. For example, after base-site 109 transmits the handoff command at a first power level, base-site 109 may wait for the elapse of the predetermined time period, and then increase the power level to a second power level during transmission of a subsequent handoff command. Likewise, base-site 109 may increase the power level of a handoff command transmission to a second power level if base-site 109 receives a reply signal transmitted by the mobile or, does not receive a reply signal transmitted by the mobile. In either case, these are valid triggering events for power level increase during handoff command transmission in accordance with the invention.

Not all handoffs require the power level increase in order to hear the handoff command, since not all geographic locations experience the same noise conditions. Some handoffs may not require as much of a signal increase as others. With this in mind, base-site 109 does not increase the signal level of signal 106 until after it has ineffectively attempted to instruct mobile 108 to handoff to an adjacent base-site 110-112. Retries at a higher downlink power level are thus performed after a predetermined triggering event, such as a time-delay, beginning with a minimal power increase. In the preferred embodiment, each successive retry receives incremental power increases until the maximum power is achieved. To illustrate that not all handoffs require the same amount of signal increase, FIG. 4 generally depicts a simulation which depicts the percentage of handoffs as they relate to the amount of additional downlink power to successfully complete

handoff. As depicted in FIG. 4, when the power level is not increased (0 dB increase), approximately 87.5% of mobiles to which a handoff command is transmitted will receive the handoff command. If the power level were increased by 10 dB, approximately 96.2% of the mobiles would receive the handoff command transmitted by the corresponding transmitting base-site 109-112. If the power level were increased by 30 dB, which is the dynamic range of transmitter 210 of the GSM cellular radiotelephone system of the preferred embodiment, almost 100% of the mobiles to which the handoff command was transmitted would receive the handoff command. As can be seen from this simulation, power level increase during handoff command transmission provides a significant increase in the probability that mobiles receive a transmitted handoff command, and thus properly execute handoff to an adjacent base-site.

Thus, it will be apparent to one skilled in the art that there has been provided in accordance with the invention, a method and apparatus for providing power level increase during handoff command transmission that fully satisfies the objects, aims, and advantages set forth above.

While the invention has been described in conjunction with specific embodiments thereof, it is evident that many alterations, modifications, and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace all such alterations, modifications, and variations in the appended claims.

What we claim is:

Claims

1. A base-site in a communication system, the base-site communicating to a mobile via a signal transmitted at a first power level, the base-site comprising:

means, operating at the first power level, for commencing transmission of a handoff command to the mobile; and

means, coupled to said means for commencing transmission, for increasing a power level of the signal transmitted from the first power level to a second power level during transmission of the handoff command.

2. The base-site of claim 1 wherein said means for increasing the power level of the signal transmitted from the first power level to a second power level further comprises means for incrementally increasing the power level of the signal transmitted from the first power level to a second power level.

3. A base-site in a time-division multiple access (TDMA) cellular radiotelephone system, the base-site communicating to a mobile via a signal transmitted a first power level during a plurality of timeslots, the base-site comprising:

means for transmitting the handoff command to the mobile at the first power level during a first timeslot;

means, coupled to said means for transmitting, for increasing the power level of the signal during transmission of the handoff command from the first power level to a second power level during a subsequent timeslot.

4. The base-site of claim 3 wherein said means for increasing the power level of the signal transmitted from the first power level to a second power level further comprises means for incrementally increasing the power level of the signal transmitted from the first power level to a second power level.

5. A base-site in a code-division multiple access (CDMA) cellular radiotelephone system, the base-site communicating to a mobile via a signal transmitted at a first power level, the base-site comprising:

means for transmitting the handoff command to the mobile at the first power level;

means, coupled to said means for transmitting, for increasing the power level of the signal during transmission of the handoff command from the first power level to a second power level.

6. The base-site of claim 5 wherein said means for increasing the power level of the signal transmitted from the first power level to a second power level further comprises means for incrementally increasing the power level of the signal transmitted from the first power level to a second power level.

7. The base-site of claim 5 wherein said means for increasing the power level of the signal transmitted from the first power level to a second power level further comprises means for increasing the power level of the signal transmitted from the first power level to a second power level during a hop of the signal from one frequency of the signal to another frequency of the signal.

8. A method of handoff in a communication system having a base-site communicating to a mobile via a signal transmitted to the mobile at a first power level, the method comprising the steps of:

transmitting a handoff command to the mobile at the first power level; and

increasing the power level of the signal transmitted from the first power level to a second power level during transmission of the handoff command.

9. A method of handoff in a time-division multiple access (TDMA) cellular radiotelephone system having a base-site communicating to a mobile via a signal transmitted to the mobile at a first power level during a plurality of timeslots, the method comprising the steps of:

transmitting a handoff command to the mobile at the first power level during a first timeslot;

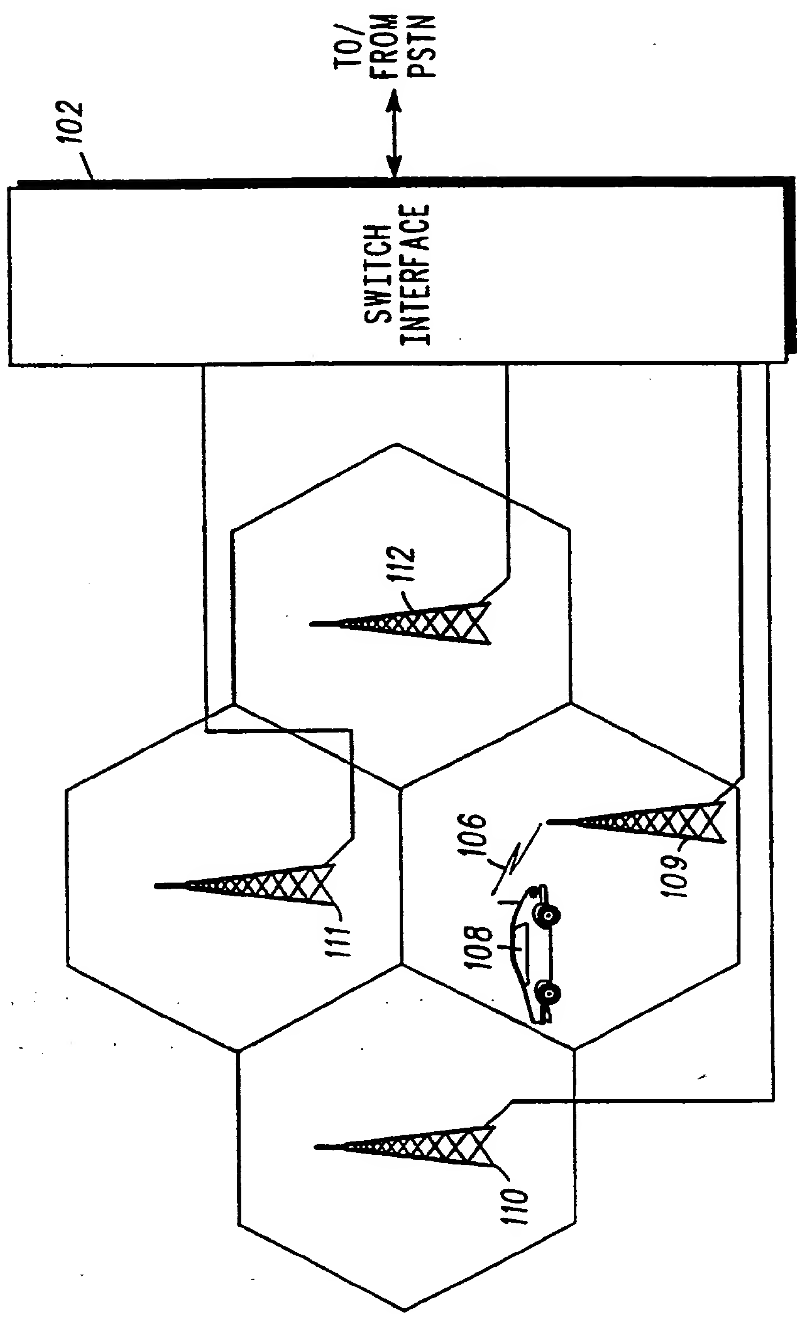
increasing a power level of the signal above the first power level during transmission of the handoff command in a subsequent timeslot.

10. A method of handoff in a code-division multiple access (CDMA) cellular radiotelephone system having a base-site communicating to a mobile via a signal transmitted a first power level, the base-site comprising:

transmitting the handoff command to the mobile at the first power level;

increasing the power level of the signal during transmission of the handoff command from the first power level to a second power level.

FIG.1



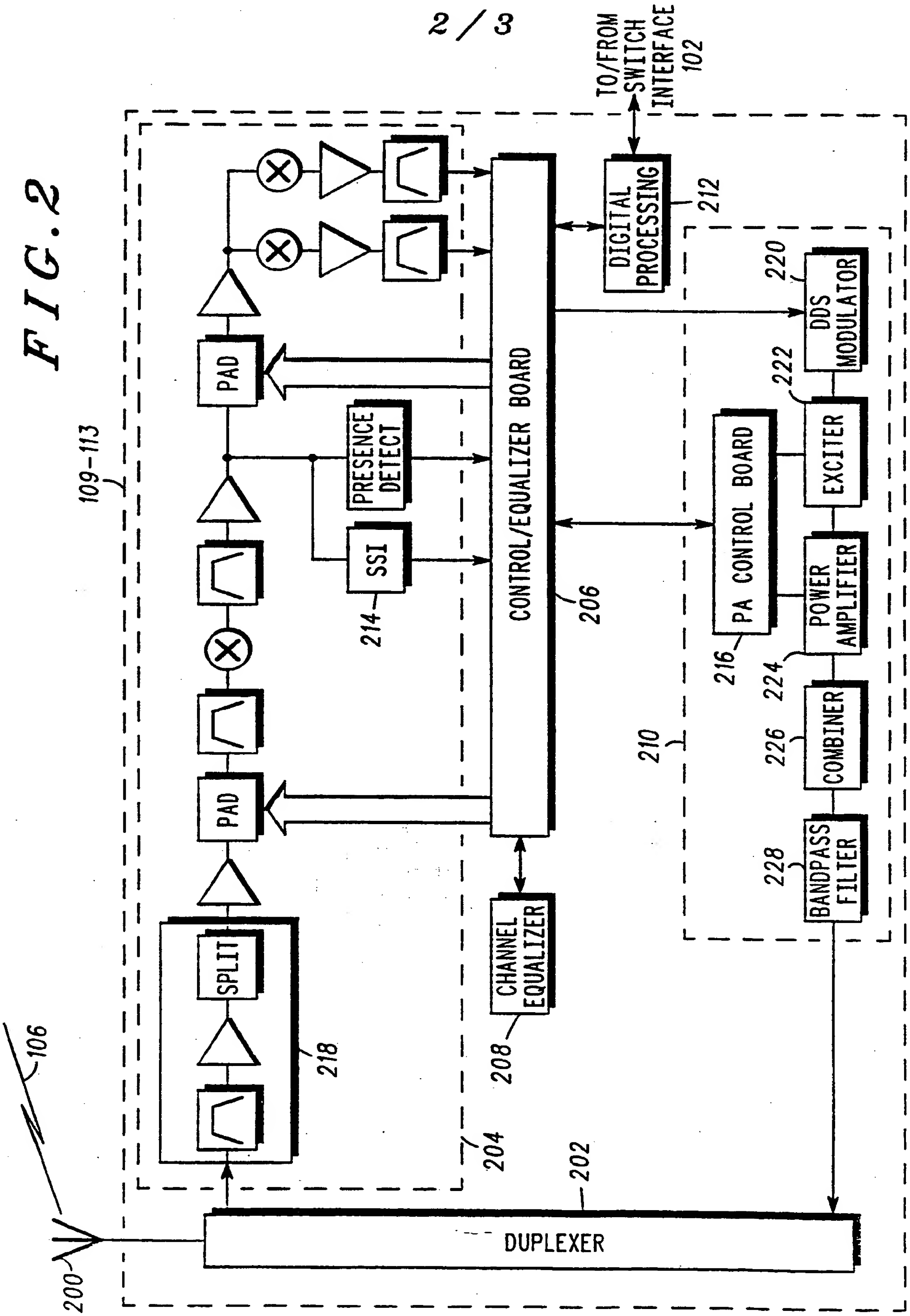

TO/FROM SWITCH INTERFACE 102
DIGITAL PROCESSING
212
CONTROL/EQUALIZER BOARD
206
DDS MODULATOR
220
EXCITER
222
PA CONTROL BOARD
216
POWER AMPLIFIER
224
COMBINER
226
BANDPASS FILTER
228
210
PRESENCE DETECT
SSI
214
PAD
PAD
SPLIT
218
109-113
CHANNEL EQUALIZER
208
204
202
DUPLEXER
200
106

FIG. 2

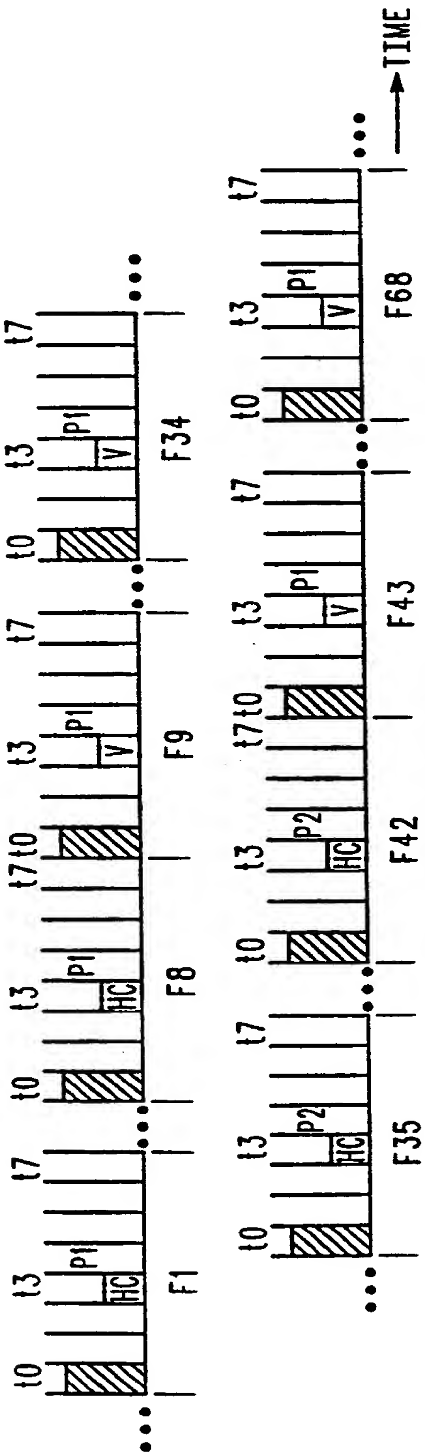

t0
t3
t7
HC
P1
P2
V
F1
F8
F9
F34
F35
F42
F43
F68
TIME

FIG. 3

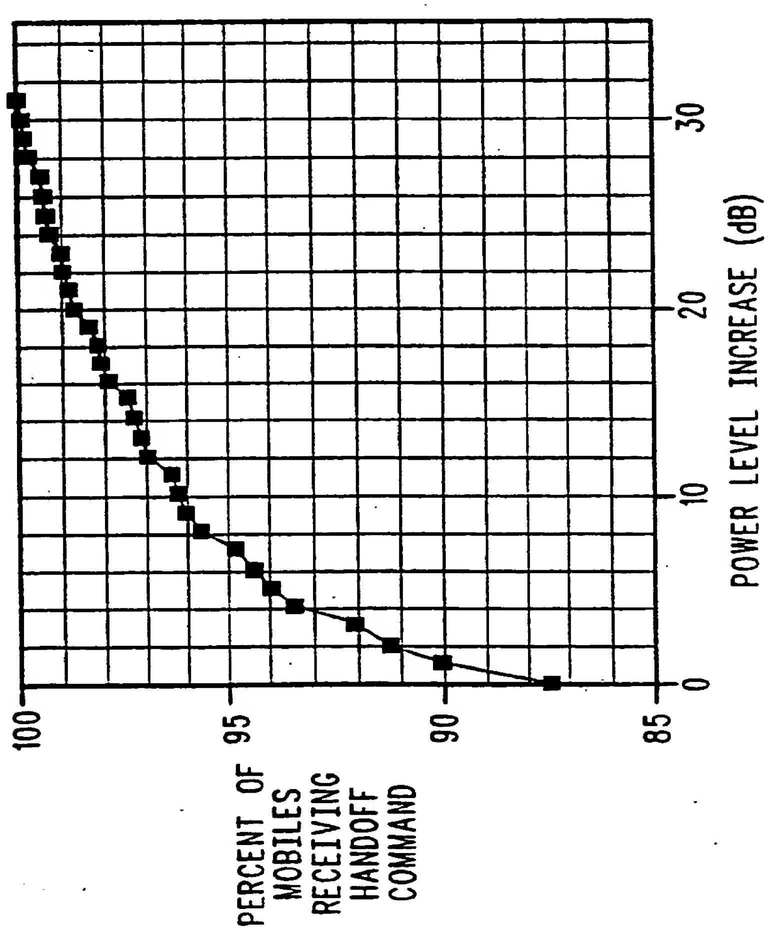

PERCENT OF MOBILES RECEIVING HANDOFF COMMAND
100
95
90
85
0
10
20
30
POWER LEVEL INCREASE (dB)

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/05078

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :H04B 7/26; H04M 11/00; H04Q 9/00
US CL :455/33.2, 54.1, 56.1; 379/60
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 455/33.1, 33.2, 33.3, 54.1, 54.2, 56.1; 379/59, 60

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

none

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A, 4,613,990 (Halpern) 23 September 1986. See col. 1, lines 43-60.	1-6 and 8-10
Y, P	US,A, 5,203,010 (Felix et al) 13 April 1993. See col. l, lines 55-69; see col. 2, lines 1-22; see figs. 3a-3c.	3-6 and 9-10
Y, P	EP, A,515,335 (Ghisler et al) 25 November 1992. See col. 2, lines 2-47; see fig. 2.	1-6 and 8-10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 09 AUGUST 1993	Date of mailing of the international search report 07 SEP 1993
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. NOT APPLICABLE	Authorized officer REINHARD EISENZOPF Telephone No. (703) 305-4819

Form PCT/ISA/210 (second sheet)(July 1992)★